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Date of RRC:	28-03-2018
Institute Registration Number:	2017PIN601
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“Investigation of the Tracking and Quality of Power in the Solar PV System”

Ph.D.Workplan

Submitted to

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1. Abstract of proposed work plan/ problem:

A PV system or solar power system is a power system designed to supply usable solar power by means of photovoltaics. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to change the electric current from DC to AC, Filters are used to control the different Parameters of Power Quality. It may also use a solar tracking system to improve the system's overall performance and include an integrated battery solution, as prices for storage devices are expected to decline.

In a PV System, there is some scope for improvement of Power Quality after the conversion of Power. Like; Noise, Harmonic Distortion, Current and voltage unbalance, Transients. These are all parameters are mostly improved by using different Active or Passive filters in the system.

Basically, in Solar PV system, there are two major parts first is PV cells and another one is (Power Electronics Interface) Interconnection conversion system which consists of other components. In that PV cell is having different efficiency and all other components are having different efficiency. The efficiency of the PV panels is around 25%. When the converter and other losses are taken into account, the efficiency can be down to16%. Whenever the output of the PV system is used for the different application it's having some power losses while converting it and there are some losses while tracking the Power. So, by using different tracking techniques, system track the maximum power very fast for more time & it will produce more Power. This will increase the Efficiency and reduce the losses of the Overall Solar PV system. To do the converting and tracking, DSP will help to control fastly.

The Proposed plan includes the survey & selection of best technique to track maximum power and improve the Power Quality of Solar PV System.

2. Introduction:

There are four main sectors: power plants, where the electrical energy is generated; the transmission grid that guides the generated energy to the clients; the distribution grid that receives the incoming energy from the transmission grid and lowers the voltage level to an adequate one for the clients; and the clients themselves that are seen as loads for this system. Each Level is having their different parameters to measure and control the Grid System. Also in Every Sector, there is some power losses and Disturbances. So, the power quality gets reduced. To change and improve Every Parameter of the Power Quality filters are used.

In the other side in Many Situations, Renewable Energy Sources are used as building blocks for smart grids. There are some interconnection circuit which includes Power Converters were established to control energy transfer from a renewable energy sources to the smart grid and also one can observe, the digital signal processing can accomplish a Different operations like; filtering operation, Tracking Operation, Smoothing Operation, Control Operation etc. so, as per the different operations DSP would help in different sections of renewable energy system. The active Power filter is the Powerful tool for mitigation of Harmonics [24].

3. Review of Literature and Development:

The use of Digital signal processing in energy sources has started since the year 1991. Mainly DSP use to Control Power Electronics circuitry (Converters) or Interconnection circuit, also in solar energy systems for Tracking, Smoothing & most of the work done in Maximum Power Pointer Tracking, where different Methods & Techniques has been developed like; Perturb & Observe ,Incremental Conductance and very frequent method is fractional open & closed circuit method[12][13]. Short-circuit current-based adaptive perturb and observe MPPT algorithm is proposed to extract the maximum power from photovoltaic (PV) panel under sudden changes in the irradiance [5]. The Short circuit current and incremental conductance MPPT methods are used, at constant temperature and irradiance short-circuit current MPPT method is efficient, economical and simple but at varying temperature, an irradiance incremental conductance is more efficient though it is complex and costlier [23].

In Brief Review of the P&O method, voltage is being increased or decreased with a fixed step size in the direction of reaching the MPP. The process is repeated periodically until the MPP is reached. At steady state, the operating point oscillates around the MPP. A variable perturbation size algorithm was developed, to reduce the oscillations and improve the response speed. However, these algorithms are not accurate and fast because they do not consider the irradiance and temperature effects, even though they are simple in implementation. Adaptive control algorithms (ACAs) are developed to address these problems. In the incremental conductance (IC) method, the slope of the PV power curve is observed to identify the MPP.If the slope is zero, then the PV panel is operating at MPP. Combination of the nonlinear and perturbation and observation (P and O) methods. The new method reduces the oscillations around the MPP and increases the average efficiency of the MPPT obtained [4].

The IC method also has the same drawbacks as presented in the P&O method, in terms of compromise between the oscillations and speed. Several IC techniques are proposed to improve the performance. For instance, some paper has suggested reducing the oscillations at MPP. But during the

rapid fluctuation of irradiance and temperature, the tracking speed reduces significantly. In another method, the open-circuit voltage (Voc) or short-circuit currents (Isc) are monitored frequently to determine the MPP voltage (Vmpp) or MPP current (Impp).These methods are known as fractional open-circuit voltage method and fractional short-circuit current (FSCC) methods. The accuracy of these methods is not guaranteed because they approximate constant ratio of Voc and Vmpp or Isc and IMPP. To overcome the disadvantages mentioned above, neural network and fuzzy logic controller based algorithms are proposed. But these algorithms require huge data storage and Complex computation structure. To overcome the disadvantages mentioned above, currently, new conventional P&O and fractional short-circuit current (FSCC) method is proposed [5]. Which also includes the realization of MPPT algorithm using the boost converter.so, all this solar system are based on the Digital Signal Processing. Conventional tracking system a single-phase inverter circuit is implemented whose switching is done by using DSP TMS320C28027 [16]. The MPPT controlled boost converter is able to reduce the inrush current and the overshoot of the output voltage of the system. The DSP TMS320F2812 Program Model for the MPPT algorithm is tested and were validated on the scope functionality in Code Composer Studio software developed by Texas Instrument [7].

The digital-signal-processor-based control provides grid-tied Converters with greater flexibility, speed, and reliability in Renewable energy systems. An inverter converts direct current (DC) into alternating current (AC) by mechanical or electronic means and makes renewable resources and energy-storage systems utility interactive. Inverters are basic components of most small and large energy systems that convert low-voltage DC power generated from a renewable energy source into higher-voltage AC power required for many residential, commercial, and industrial applications.

Instead of using two converters, a simple controlled full wave converter can be used in rectifier or inverter mode to increase the efficiency [6]. Grid-tied inverters are required in energy systems that produce or store electric energy in DC form and transfer that energy to or from an AC power system. Typical energy systems include solar photovoltaic (PV), wind turbines, batteries, and fuel cells. Grid-tied inverters were considered unreliable when they were first commercially introduced in the early 1980s. Their problems were attributed to the lack of quality control that comes from mass production. A new grid-tied inverter technology is based on the use of a state-of-the-art Texas Instruments digital signal processor (DSP) controller and the inventor's proprietary software. The advantages expected from a DSP-based control algorithm include increased reliability, the fast response resulting in high performance, low cost of implementation, and flexibility of control. In addition, the currently proposed control method will be capable of maintaining the stiffness of the AC voltages at the point of common coupling, regardless of variation in the input DC bus voltage, without any additional costs or components. Also, the problem of mismatch between the solar arrays and the given load is overcome by controlling by DSP [14].

In the area of Power electronics (Power converters) which are used in Renewable energy systems, as we view in the recent day's converters places very important role in the energy system. The buck-boost converter is one of the type of DC-DC converter from that converter getting the output of the both stepped up & stepped down voltage depending on the duty cycle ratio of PWM signal. In normal buck-boost converter, use of only one switch (MOSFET), a diode and output are negative, either buck or boost condition. Because of this solar energy output is not inverted.so, for overcoming this drawback some work is going on for DSP based controller for DC-DC Converter. To improve the working of converter High-Frequency transformer is added to the converter and the control algorithm of a converter is built using a spectrum digital eZdspTM TMS320F2812 card [19]. A non-Inverting or Positive output buck-boost Converter is implemented for PV System. The PWM signals for Two MOSFET Switches in the converter circuit are generated from DSP TMS320F28335. This system is

better as compared to the existing system in terms of both line and load regulation, also efficiency is 92% [21]. Also, Some Active Filters are Design to Improve the Power Quality of the PV system [24].

The Development of Digital Signal Processing in renewable energy system is mostly in Power Electronics interface (Interconnection Circuit) of energy systems and also in the solar energy Systems.

4. Objectives of Research/ Proposed Hypothesis:

The main goal of the work is to overcome the problems in Power Quality of any renewable energy systems by using DSP (Digital Signal Processing).

The task is divided into smaller objectives which need to be carried out in order to achieve the goal. These objectives are:

1. Review of simulation module of solar PV system.
2. Review of different algorithms of maximum power point tracking techniques.
3. Selection of (MPPT) Maximum Power Point Tracking Technique
4. Survey and selection of filter to enhance different power quality parameters.
5. Implement a filter to reduce the Following parameters in PV System

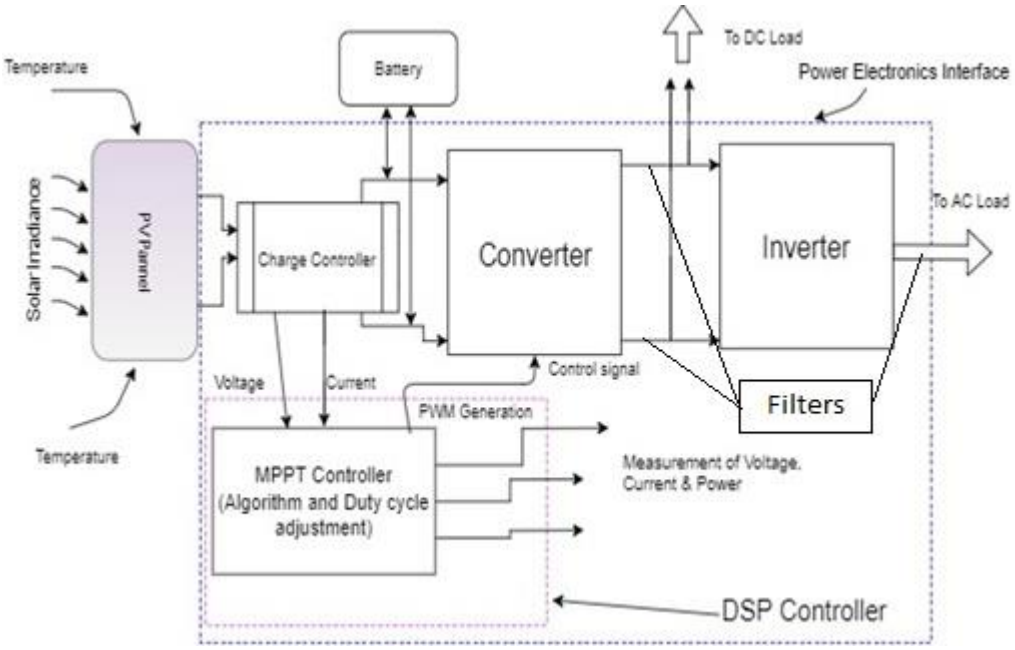
   I. Noise II. Distortion III. Current and voltage unbalance IV. Transients V. Voltage sag & Swell
6. Simulation modelling of the overall PV system with efficient power tracking system and filter.
7. Improved DSP based Maximum Power Point Tracking (MPPT) method for PV Systems.
8. Verification and Comparison of the results.

5. Methodology to be adopted:

As per the review of the Renewable energy systems, there is more advantage to used DSP. The main focus is on the power tracking and power quality. For developing any energy system it's having Power electronics circuitry with contains different Power converters as per the different energy systems, that converters are having a number of disadvantages, to overcome those problems new topologies are developed for a different type of converters, also DSP based controller are designed for buck-boost converters. But after conversion there are some problems with power quality, to enhance the power quality many filters are used like; Shunt active Filter, LC and LCL Passive Filters, Hybrid Filter [22].

Every Energy system is connected to the Smart grid by interconnection circuit, so for the purpose of that, currently new technique is developed by using Processor. The purpose of the new technique is to control the amount of energy transferred from the renewable energy sources to the smart grid, following in the same time and taking into account the smart grid frequency. In order to determine high accuracy in smart grid frequency and also for the PWM control of the power inverter, DSP is required to the convenient solution.so, by overcoming some problems final model is to develop [21].

A system designing technique called Model-Based Design is gaining massive success as it leads to rapid prototyping. It provides the pathway through which the designed simulation model can be used to generate code and that code can be fed into the system controller. Industries are replacing their generic designing techniques with Model-Based Designing as it cuts the development time significantly. Model-Based Designing is possible through MATLAB as it provides the groundwork for it. Embedded Coder by MATLAB is used for this purpose, which provides controller specific code which can be flashed into the DSP controller.



6. Importance of study/ Society application:

- International status / National Status:

Research on DSP Based Renewable grid converter has started in the international arena since the early 1990s. The research is started from Maximum Power Point Tracking converters for PV system.

In 1980 has started the study on the dynamic behaviour of the Solar system. In 1991 J.H.R.Enslin include an MPPT for cost-saving necessity in solar systems. Afterword's He has includes some new techniques for MPPT like; economical PV MPPT regulators (1994), Integrated Photovoltaic MPPT converter (1997) then there are a lot of techniques developed by other author's MPPT Using Positive feedback [1], DSP-Controlled PV system with Peak power Tracking (1998) [14] ,MPPT using Switching frequency modulation (2004). In 2000s MPPT includes P&O Method for tracking, which improved in 2007 as current based and voltage based MPPT. New Direct Torque and Power Control strategies for converters are developed in 2007. Then new direct power control with space vector modulation scheme for grid power converters are proposed in 2011.An Adaptive digital control technique for improved performance of grid-connected inverters is proposed in 2013 which includes IIR filter Structure. In 2014 an Indian author has proposed new short circuit current based adaptive perturb and observe MPPT is proposed to extract the max power from PV panel under sudden changes in the irradiance [23]. In 2016 & 2017 some MPPT tracking, converters control, and energy filters are

proposed [24]. Currently, as per the national status, most of the work is going on in IIT Kharagpur, IIT Bhubaneswar, and IIT Powai.

Currently, most of the researchers are working on the Interconnection circuit or power electronics converters for MPPT converter for PV Systems which also includes power quality and energy storage applications.

- Significance of the study :

Solar PV system is having an interconnected circuit or power Electronics Interface which includes Power Converters. Where Converters are used to transferring the energy to the grid while transferring the energy there are some problems like; low frequency, Accuracy, delay in time, Power Control, Efficiency, Power Quality issues etc. these all problems are included in Solar PV system. So, to overcome this problem digital signal processor is very useful to control [16]. For example, the processor TMS320F28087 has important features, that can be exploited in the specific application, such as High efficiency 32 bit CPU, special instruction for signal processing, analog to digital converter, PWM modules, Capture module, a high resolution set of timers and so on. It also improves the steady-state and dynamic characteristics response of the system.

On the other side, we can use DSP in Energy System for tracking in PV systems, filtering, power Smoothing, Processing using Energy storage [23]. Also, the DSP based energy system will also improve the different parameters of Power Quality like; sag, swell, fluctuations, harmonics, offsets etc. which will give very good accuracy for the overall system. So, the Digital signal processing is very useful to control the different parameters of power Electronic interface and all energy systems.

7. Proposed work Plan- with a tentative chapter scheme:

- Chapter 1: Introduction and Literature Survey.
- Chapter 2: Simulation of Photovoltaic Module.
- Chapter 3: Survey and Selection of Various MPPT Techniques.
- Chapter 4: Survey of Different Filters to Improve the Parameters of Power Quality.
- Chapter 5: Selection & Implementation of Filter.
- Chapter 6: Simulation modelling of the Overall PV system with Efficient Power tracking system and Filter
- Chapter 7: Improved DSP based Maximum Power Point Tracking (MPPT) method for PV Systems
- Chapter 8: Comparison and Results Analysis.
- Chapter 9: Future Scope and Conclusion.

8. Year-wise Plan of work and targets to be achieved

1st Year (2017-2018)	2nd Year (2018-2019)	3rd Year (2019-2020)
- Collection of Literature and Detail Specifications Renewable Energy Systems. - Simulation of PV System.	- Survey and Selection of Filter to Improve Different Power Quality Parameters - Implement Filter and Compare	Verification, Comparison of the result & Paper Writing.
- Review of Different algorithms of Maximum Power Point Tracking Techniques - Selection of Maximum Power Point Tracking Technique	- Use of Filter to Improve Power Quality Parameters. - Simulation modelling of the Overall PV system with Efficient Power tracking system and Filter.	-Research and Paper writing -Thesis Writing

9. Expected Outcome:

Improve the Performance of the PV system by,

1. Found the best Maximum power tracking system of PV system to track maximum power.
2. Enhance the Power Quality.
3. Control the Different Parameters of the PV system fastly.
4. Increase the Efficiency of the Overall PV system.

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